NON-TECHNICAL SUMMARY

Environmental Survey Of Potential Sand Resource Sites: Offshore New Jersey

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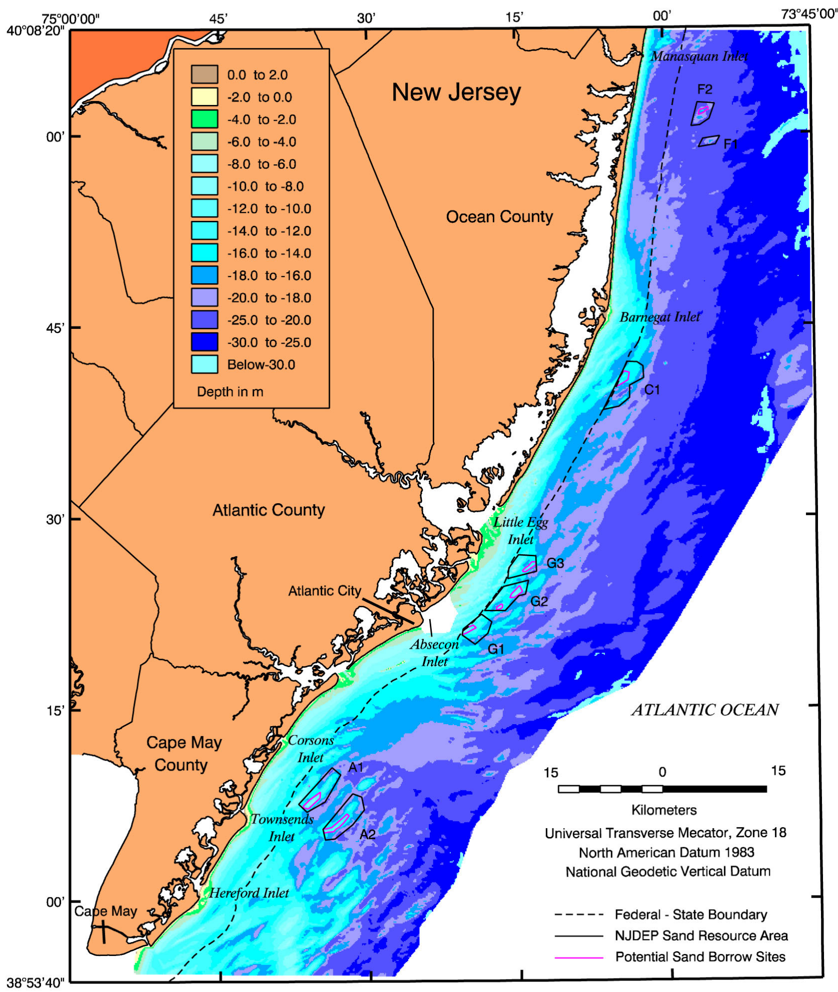

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MMS
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ENVIRONMENTAL SURVEY OF POTENTIAL SAND RESOURCE SITES: OFFSHORE NEW JERSEY

In recent years, there has been increasing interest in sand and gravel mining on the Outer Continental Shelf (OCS). The U.S. Minerals Management Service (MMS) has significant responsibilities with respect to the potential environmental impacts of sand and gravel mining. Existing regulations governing sand and gravel mining provide a framework for comprehensive environmental protection during operations. Guidelines for protecting the environment stem from a wide variety of laws, including the OCS Lands Act (OCSLA), National Environmental Policy Act (NEPA), Endangered Species Act, Marine Mammal Protection Act, and others. Regulations require activities to be conducted in a manner which prevents or minimizes the likelihood of any occurrences that may cause damage to the environment.

Under the OCSLA, the MMS is required to conduct environmental studies to obtain information useful for decisions related to negotiated agreements and lease activities. As such, the MMS pursues its responsibilities for management of offshore sand and gravel mining by:

- protecting ocean and coastal environments by ensuring that all OCS sand and gravel mining activities are environmentally acceptable;
- ensuring that OCS sand and gravel activities are compatible with other uses of the ocean;
- involving coastal States in all aspects of sand and gravel mining activities; and
- evaluating the potential of the OCS as a domestic source for sand and gravel resources.

To this end, the MMS has initiated environmental studies along the U.S. Atlantic and Gulf coasts to provide information for programmatic marine mining decisions at MMS Headquarters and OCS Regional Offices. The report discussed in this summary presents results from one of the environmental studies administered through the MMS International Activities and Marine Minerals Division (INTERMAR). Entitled “Environmental Survey Of Potential Sand Resource Sites: Offshore New Jersey”, this program was initiated by Aubrey Consulting, Inc. (ACI) in August 1997 under MMS Contract No. 14-35-01-97-CT-30864. The Final Report was prepared by Applied Coastal Research and Engineering, Inc. (Applied Coastal) in cooperation with Continental Shelf Associates, Inc. (CSA), ACI, and Barry A. Vittor & Associates, Inc. (BVA).

BACKGROUND

The inshore portion of the continental shelf, seaward of the Federal-State OCS boundary and within the New Jersey Exclusive Economic Zone (EEZ), encompasses the project study area (Figure 1). The seaward limit of the study area is generally within about 20 km of the shoreline. Sand resource areas are located on the New Jersey OCS between the 10- and 20-m depth contours. The continental shelf surface within the study area contains many first-, second-, and third-order morphologic features formed during the Holocene transgression. Sand ridges 2- to 5-m high and 0.5- to 1.5-km apart represent second-order features that are the primary sand resource targets of this study.

Eight potential sand resource areas were defined within the study area through a Federal-State cooperative agreement between MMS-INTERMAR and the New Jersey Geological Survey (NJGS). For this study, seven borrow sites within Sand Resource Areas A1, A2, G1, G2, G3, C1, and F2 were defined to evaluate potential impacts of sand mining for beach replenishment. Sand Resource Area F1 was not included in the physical processes analysis because the quantity of sand available for beach nourishment is small (<1 million cubic meters

[MCM]) relative to basic replenishment needs, and water depths are greatest in this region, making potential dredging operations more complicated and costly.

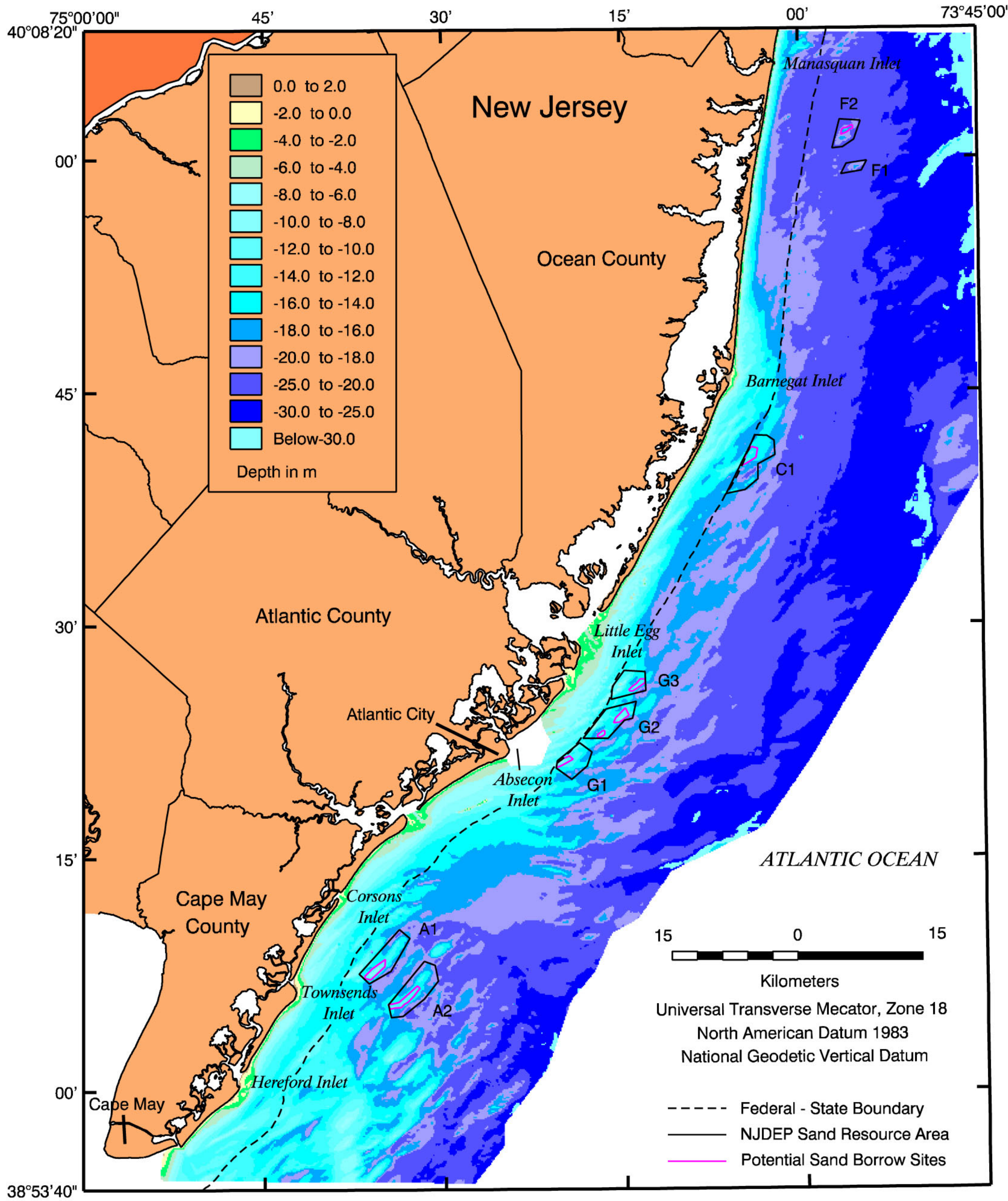

Figure 1. Location of New Jersey study area and potential sand resource areas.

PURPOSE

The primary purpose of this study was to address environmental concerns raised by the potential for dredging sand from the OCS offshore the State of New Jersey for beach replenishment and to document the findings in a technical report. The primary environmental concerns focused on physical and biological components of the environment. To this end, seven study objectives were identified:

- Compile and analyze existing oceanographic literature and data sets to develop an understanding of environmental conditions offshore New Jersey and the ramifications of dredging operations at selected sand borrow sites;
- Design and conduct biological field data collection efforts to supplement existing information;
- Analyze physical and biological data sets to address basic environmental concerns regarding potential sand dredging operations;
- Use physical processes data sets and wave climate simulations to predict wave transformation under natural conditions and in the presence of proposed dredging activities;
- Determine existing coastal and nearshore sediment transport patterns using historical data sets, and predict future changes resulting from proposed sand dredging operations;
- Evaluate the potential environmental effects of multiple dredging scenarios; and
- Develop a document summarizing the information generated to assist with decisions concerning preparation of an Environmental Assessment/Impact Statement to support a negotiated agreement.

It is expected that information presented in the Final Report will enable the MMS to identify ways in which dredging operations can be conducted to minimize or prevent long-term adverse impacts to the marine environment.

SIGNIFICANT CONCLUSIONS

The following discussion provides a summary of results and conclusions regarding the potential environmental effects of sand mining on the OCS for replenishing sand to eroding beaches. Because benthic and pelagic biological characteristics are in part determined by spatially varying physical processes throughout the study area, physical processes analyses are summarized first.

Wave Transformation Modeling

A primary component of any physical environmental effects analysis related to sand mining from the OCS should include computer modeling of wave movement from offshore to the coast. Potentially rapid and significant changes in seafloor shape due to sand dredging from the OCS may have substantial impact on wave patterns across the continental shelf and at the shoreline. In turn, sediment movement on the seafloor and at the beach may be altered so as to adversely impact erosion problems being mitigated. As such, substantial effort was spent understanding existing wave patterns relative to those resulting from potential sand dredging activities.

A spectral wave model was selected to simulate changing wave patterns because of its ability to propagate individual components of a wave energy distribution (a spectrum) simultaneously across the continental shelf. By simulating several wave components simultaneously, a spectral wave model represents nature more closely. Rather than selecting the most common wave heights and directions as model input, a detailed analysis was conducted to summarize existing wave data into average directions and spectra. Each direction may contain distinct differences in energy and/or directional spectra, and consequently produce varying impacts at borrow locations. Simulation of these wave characteristics (averaged over 20 years) provides a method of identifying these changes. In addition, a storm event (50-yr storm) was developed to investigate potential impacts during high energy conditions. These simulations then provided the basis for nearshore circulation and sediment transport modeling.

Wave modeling results indicate that minor changes will occur to wave fields under typical non-storm waves and sand extraction scenarios representing multiple beach nourishment events. Non-storm significant wave heights and wave angles experience little variation to the 20-m depth contour where the wave field begins to feel the influence of the seafloor. The region offshore of Townsends and Corsons Inlets has a relatively consistent longshore wave height distribution. Several areas of wave convergence and divergence were caused by the shoals surrounding Sand Resource Areas A1 and A2. These features focus wave energy at various locations along the coast depending on the wave approach direction. The area to the south of Barnegat Inlet experiences mild shoreline retreat and a consistent wave height distribution along the shoreline. Shoals and depressions south of Area C1, as well as offshore linear ridges to the north, can produce significant wave alterations. Wave energy focused by these features most often impact the Harvey Cedars and Loveladies regions. Offshore Little Egg and Brigantine Inlets, wave propagation again is influenced by numerous linear ridges. Increased wave heights appear most frequently near Brigantine Inlet. The area seaward of northern Barnegat Bay also experiences wave height changes produced by offshore shoals and depressions. Consistent wave focusing by shoals in and around Area F2 is prevalent. Wave energy focused by these features may impact regions from Seaside Park north to Bay Head, depending on approach direction. For a 50-yr hurricane and northeast storm, wave patterns are similar to the directional approach results. An increase in wave height is documented in many areas where wave convergence occurs.

Differences in wave height between pre- and post-dredging simulations for offshore New Jersey indicate maximum wave height changes ranging from 0.1 to 0.25 m (7 to 16% of the initial wave height). The magnitude of modifications increase as the magnitude of waves increase or when the orientation of potential borrow sites aligns with waves to produce maximum impact (e.g., southeast approach at Grid A). For model grids encompassing Resource Areas A and G, maximum wave height changes dissipate relatively quickly as waves advance towards the coast and break. For model grids in the northern part of the study area (Areas C and F), maximum changes do not dissipate as readily. At potential impact areas along the coast, wave height changes average ±0.13, ±0.15, ±0.11, and ±0.10 m for Areas A, G, C, and F, respectively. These modifications represent changes of approximately ±3 to 15% when compared with wave heights for existing conditions. Overall, there is minimal to no impact caused by potential offshore dredging during normal conditions.

During extreme conditions (e.g., a 50-yr storm), wave heights are increased from 0.4 to 1.4 m, suggesting a rather significant change. However, as a result of the increased magnitude of incoming waves, this generally represents a change of less than 10%. Due to the orientation of the shoreline and the proposed borrow sites, a hurricane has more significant impacts on Areas A and G, while a northeast storm more significantly impacts Areas C and F. For most of the sand borrow sites, a significant amount of wave energy is dissipated before waves reach the coast. As such, wave height increases are less than 0.4 m along most of the coast. A maximum change of 0.4 m in wave height is not expected to increase nearshore erosion above existing conditions during a storm event.

Circulation and Sediment Transport Dynamics

While no large-scale predictive circulation models were developed to quantify the effects of dredging in sand resource areas, the analysis of current patterns resulting from this study suggests proposed sand mining will have negligible impact on large-scale shelf circulation. Measurement of bottom currents offshore New Jersey (seaward of Little Egg Inlet) throughout an approximate two-year period (1993 to 1995) revealed considerable variability in flow speed and direction. The mean flow was to the southwest along the inner shelf bathymetric contours. Strongest flow was observed in the along-shelf direction, with peak velocities of nearly 50 cm/sec (1 knot) to the south; maximum northward currents reached 37 cm/sec. Flow reversals were noted frequently.

In the cross-shelf direction, mean flow was oriented onshore, consistent with upwelling processes that push bottom waters up onto the shelf. Maximum cross-shelf flow was 31 cm/sec (directed onshore); minimum flow was -13 cm/sec (directed offshore). Cross-shelf bottom currents were affected most significantly by semi-diurnal tides, with a mean onshore flow. Wind-driven currents were found to be less significant in the cross-shelf direction. Seasonal variability was most significant for wind-driven currents. Winter and autumn data records were most energetic, with summer and spring data sets possessing smaller energy values.

These data suggest that along-shelf currents possess higher energy than cross-shelf flows. Along-shelf currents were dominated by wind-driven processes, accounting for as much as 70% of the total current energy. Wind-driven processes were greatest in winter; however, wind-driven flows appeared strongly biased by singular events, such as local responses to storm winds or non-locally generated free waves that influenced the magnitude of wind-driven current energy. This evidence suggests that these singular events, with corresponding higher currents, have the greatest potential to transport sand. If so, sediment transport patterns are predominately in the along-shelf direction, with a net transport oriented in the direction of the mean southerly flow.

Three independent sediment transport analyses were completed to evaluate impacts due to offshore sand dredging. First, historical sediment transport trends were quantified to document regional, long-term sediment movement throughout the study area using historical bathymetry data sets. Second, sediment transport patterns at proposed offshore borrow sites were evaluated using wave modeling results and current measurements. Third, nearshore currents and sediment transport were modeled using wave modeling output to document potential impacts to beach erosion and accretion. All three methods were compared for evaluating consistency of measurements relative to predictions, and potential impacts were identified.

Historical Sediment Transport Patterns

Regional geomorphic changes for the period 1843/91 to 1934/77 were analyzed to assess long-term, net coastal sediment dynamics. Although these data did not provide information on the potential impacts of sand dredging from proposed borrow sites, they do provide a means of calibrating predictive sediment transport models relative to infilling rates at borrow sites and longshore sand transport.

A comparison of erosion and deposition volumes at proposed borrow sites provided a method for quantifying sediment transport rates (or borrow site infilling rates). Alternating bands of erosion and accretion on the continental shelf east of the Federal-State boundary illustrate relatively slow but steady reworking of the upper shelf surface as sand ridges migrate from north to south. The process by which this is occurring at Areas G1, G2, and G3 suggests that a borrow site in this region would fill with sand transported from an adjacent site at a rate of about 62,000 to 125,000 m^3/yr. At Areas A1 and A2, the potential sand transport rate increases to

160,000 to 200,000 m^3/yr. This increase in potential transport rate reflects a more dynamic offshore environment seaward of the southern barrier island chain.

Net longshore transport rates determined from seafloor changes in the littoral zone between Little Egg Inlet and the beach south of Hereford Inlet indicate an increasing transport rate to the south from about 70,000 m^3/yr south of Little Egg Inlet to 190,000 to 230,000 m^3/yr at Townsends and Hereford Inlets. It appears that areas of largest net transport exist just south of entrances as a result of natural sediment bypassing from updrift to downdrift barrier beaches. These rates compare well and provide a measured level of confidence in wave and sediment transport modeling predictions relative to impacts associated with sand dredging from proposed borrow sites.

Sediment Transport at Potential Borrow Sites

In addition to predicted modifications to the wave field, potential sand mining at offshore borrow sites results in minor changes in sediment transport pathways in and around the dredged regions. The modifications to bathymetry caused by sand mining only influence local hydrodynamic and sediment transport processes in the offshore area. Although wave heights may change at the dredged borrow sites, areas adjacent to the sites do not experience dramatic changes in wave or sediment transport characteristics.

Initially, sediment transport at borrow sites will experience rapid changes after sand dredging is complete. Given the water depths at the proposed borrow sites, it is expected that minimal impacts to waves and regional sediment transport processes will occur during infilling. Sediment that replaces the dredged material will fluctuate based on location, time of dredging, and storm characteristics following dredging episodes. Average transport rates range from a minimum of 28 m^3/day (about 10,000 m^3/yr; Area F2) to a high of 450 m^3/day (about 164,000 m^3/yr; Area A1), while the infilling rate varies between 54 (Area A1) to 303 years (Area C1). This range of infilling times is based on the volume of sand numerically dredged from a borrow site as well as the sediment transport rate. Predicted nearshore sediment transport rates are slightly lower than those determined from historical data sets, but the two rate estimates are within the same order of magnitude (10,000 to 160,000 m^3/yr versus 62,000 to 200,000 m^3/yr, respectively). Calculated infilling times would be reduced if storm events were incorporated into the analysis.

Nearshore Sediment Transport Modeling

The potential effects of offshore sand mining on nearshore sediment transport patterns are of interest because dredged holes can intensify wave energy at the shoreline and create erosional hot-spots. Sand dredging impacts for Areas A1 and A2 illustrate that there is a defined, but minor, change in littoral transport. Due to relatively high transport rates along the southern portion of the New Jersey coast, the percent difference in transport rates associated with dredging was smallest within this area (the maximum variation in annual longshore sand transport rate was approximately 7% of the existing value). The shadow zones landward of Areas A1 and A2 are located approximately 5 km and 1 km north of Townsends Inlet, respectively. These shadow zones are indicated by a significant reduction in south-directed wave energy.

Because the offshore distance to Resource Areas G2 and G3 is relatively small (approximately 5 km offshore), the region of potential impacts is more confined than the area defined for Area A2. For the borrow sites in Areas G2 and G3, the maximum variation in annual longshore sand transport rate is approximately 9% of the existing value. The largest increase in south-directed transport occurs approximately 2 km south of Brigantine Inlet. For Resource Area C1, the combined effect of various wave conditions tends to mute the increase in south-directed sediment transport, where the largest increase is approximately 3,000 m^3/yr. Although the maximum variation in annual longshore sand transport rate is approximately 20% of the existing average value, the relatively high percentage of the 45,000 m^3/yr net transport indicates similar impacts as those predicted for Grids A and B2.

For the borrow site in Area F2, the maximum variation in annual longshore sand transport rate is approximately 17% of the existing value. Similar to Grid B1, the relatively low net sediment transport indicates a high percentage of impact to the transport rate; however, the maximum change of approximately 12,700 m^3/yr is similar to the modeled change for Grids A, B2, and B1. An increase in wave energy at the shoreline is responsible for the increased north-directed transport.

Overall, the potential impacts of offshore sand dredging throughout coastal New Jersey appear to be minimal relative to offshore and beach sand transport patterns. For average annual conditions, mean longshore sand transport rates were approximately equal landward of borrow sites in resource areas along the New Jersey coast. The absolute value of the mean difference between existing and post-dredging conditions was relatively consistent, ranging between 9,000 and 14,900 m^3/yr.

Benthic Environment

Results of the May and September 1998 biological field surveys agree well with previous descriptions concerning benthic (bottom) organisms associated with shallow shelf habitats offshore New Jersey. Seafloor communities surveyed from the eight proposed sand resource areas consisted of members of the major invertebrate (for example, worms, crabs, and clams) and vertebrate (for example, fishes associated with the seafloor) groups that are commonly found in the study region. Statistical analysis indicated that the composition of seafloor communities inhabiting resource area stations was affected mostly by the percentage of gravel composition of surficial sediments. The abundance of organisms living in the seafloor (infauna) reflected sediment type distributions. Trough and sand ridge features further contributed to the spatial variability exhibited by seafloor communities in the sand resource areas. Temporal differences were apparent as well. Nearly half of infaunal taxa were included in the May and September surveys; however, most (68%) of the remainder of censused taxa were collected only during the September cruise. Overall, the abundance of infauna was higher during the May survey than was observed in September. Both the numbers of taxa and individuals for organisms living on the seafloor (epifauna) were greater in September survey as compared with May. Fished associated with the seafloor that were collected during the surveys included bay anchovy, clearnose skate, northern searobin, scup, and windopane.

Potential effects to bottom-dwelling organisms from dredging will result from sediment removal, suspension/dispersion, and deposition. Primary effects to organisms associated with the bottom will be removal with sediments during dredging. Effects are expected to be short-term and localized. Seasonality and recruitment patterns indicate that removal of sand between late fall and early spring would result in less stress on benthic populations. Early-stage succession will begin within days of sand removal, through settlement of young recruits, primarily worms and clams. Immigration of larger mobile animals also will begin soon after dredging. Later successional stages of benthic recolonization will be more gradual, involving organisms that generally are less opportunistic and longer lived.

While community composition may differ for a period of time after the last dredging, the benthic community type that exists in mined areas will be similar to naturally occurring assemblages in the study area, particularly those assemblages inhabiting inter-ridge troughs. Based on previous observations of recolonization in dredged areas, the benthic community in dredged sites within sand resource areas most likely will become reestablished within 2 years, exhibiting levels of abundance, diversity, and composition comparable to nearby non-dredged areas. Given that the expected beach replenishment interval is on the order of a decade, and that the expected recovery time of the affected benthic community after sand removal is anticipated to be much less than that, the potential for significant cumulative benthic impacts is remote.

Atlantic surfclam is the most economically important benthic species found in or around the sand resource areas. National Marine Fisheries Service data indicate that the likelihood of encountering Atlantic surfclams in any of the New Jersey sand resource areas is reasonably high. Primary effects of dredging on Atlantic surfclam would be entrainment, hypoxia/anoxia, and turbidity. Project scheduling would not be useful for avoiding dredging-induced impacts to Atlantic surfclams. Once an exact borrow site is chosen for dredging, a commercial clam fisher should be hired to evaluate the site for the presence and abundance of Atlantic surfclams. If commercial quantities are found, then the fisher should harvest them from the site prior to dredging. This approach would remove individuals that would be subject to impacts. Studies have demonstrated that juvenile Atlantic surfclams will recruit to dredged borrow sites.

Pelagic Environment

Zooplankton (animals living in the water column that drift with currents), squids, fishes, sea turtles, and marine mammals were groups in the pelagic environment considered to be potentially affected by offshore dredging. No cumulative effects to any of these groups are expected from multiple sand mining operations. Zooplankters could be affected by entrainment and turbidity. Considering the high reproductive capacity of zooplankton along with the relatively small area of the dredge suction field and the volume of water entrained compared to the overall volume of surrounding waters, it is unlikely that entrainment or turbidity would greatly affect zooplankton populations or assemblages in the New Jersey sand resource areas. If borrow sites are used in Areas G1, G2, or G3, an environmental window excluding summer and fall months could be considered to avoid dredging when fish juveniles and larvae are most prevalent, but only if additional data become available to determine the extent of impacts and justify the restriction.

Some squids and squid eggs could be removed by dredging but this is unlikely to significantly impact squid populations. This precludes the need for an environmental window or specific project scheduling to protect squid resources

Dredging should not present a significant problem for pelagic fishes offshore of New Jersey. Potential effects to fishes could occur through entrainment, attraction, and turbidity. If an environmental window is sought to protect pelagic fishes from dredging impacts, the spring to fall period would encompass the peak seasons for the economically important species. Quantitative data are lacking to support the use of an environmental window to lessen effects on pelagic fishes. Essential fish habitat (EFH) for several fish species (and life stages) overlap the eight sand resource areas offshore New Jersey. The area encompassed by the eight sand resource areas is very small relative to the mapped EFH characteristics. For this reason, the effect of dredging on EFH for the managed species is expected to be minimal.

The main potential effect of dredging on sea turtles is physical injury or death caused by the suction and/or cutting action of the dredge head. No significant effects on turtles are expected from turbidity, anoxia, or noise. Three sea turtle species that typically occur off New Jersey (loggerhead, green, and Kemp's Ridley) are considered to be at risk because of their benthic feeding habits. Loggerheads are the most abundant turtles in the project area, and historically, they have been the species most frequently entrained during hopper dredging. If a hopper dredge is used, then it would be best to avoid the June through November turtle season. If this period can not be avoided, other mitigation requirements may be appropriate, such as turtle monitoring and use of a turtle-deflecting draghead.

Marine mammal species occurring commonly on the shelf, such as bottlenose dolphin and common dolphin, may be present year-round but are unlikely to be adversely affected by dredging due to their agility. Harbor porpoise occurrence is more seasonal, but the likelihood of impact is so low that it does not warrant seasonal restrictions on dredging. Fin and humpback whales would be most likely to occur during winter or spring, and northern right whales as transients during spring and fall. There is no “resident” population of any of these whales in the study area; rather, they would be temporary inhabitants, or would be transiting the area during seasonal migrations. Generally, the probability of encountering these species in the project area would be lowest during summer. However, due to the low likelihood of impact, seasonal restrictions on dredging probably are not warranted. Instead, measures to minimize possible vessel interactions with these endangered species may be appropriate.

SYNTHESIS

Minimal physical environmental impacts due to potential sand dredging operations have been identified through wave and sediment transport simulations. Under normal wave conditions, the average change in longshore sand transport is about 13% of existing conditions. Because wave and sediment transport predictions are only reliable to within about 25 to 35%, predicted changes are not deemed significant. Although changes during storm conditions illustrate greater variation, the ability of models to predict storm wave transformation and resultant sediment transport is less certain. Because minor impacts to wave and sediment transport dynamics and biology may occur under conditions similar to those imposed in the present study, additional data collection and analysis may be required for a specific sand extraction scenario to determine the extent of impacts.

The data collected, analyses performed, and numerical modeling conducted for this study indicate that proposed sand dredging at sites evaluated on the OCS offshore New Jersey should have minimal environmental impact on fluid and sediment dynamics and biological communities. Short-term impacts to benthic communities are expected due to the physical removal of borrow material, but the potential for significant cumulative benthic impacts is remote. Additionally, no cumulative effects to any of the pelagic groups are expected from potential sand mining operations.

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